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DEPARTMENT OF BOTANY

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# FUNGICIDES IN THE APPLE ORCHARD

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By CHARLES BROOKS

NEW HAMPSHIRE COLLEGE
OF
AGRICULTURE AND MECHANIC ARTS
DURHAM, N. H.

NEW HAMPSHIRE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS

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# FUNGICIDES IN THE APPLE ORCHARD.

CHARLES BROOKS.

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The following bulletin is a summary of five years of spraying experiments in the apple orchards of New Hampshire. In carrying out the work the control of particular diseases and the action of special fungicides have been kept in view as well as the general care of the orchard.

## THREE YEARS' WORK IN McINTOSH ORCHARDS.

In the summers of 1907, 1908 and 1909 spraying experiments were made in the McIntosh orchards of Arthur G. Ladd and Jonathan Smith of Deerfield, N. H. The primary purpose of the work was to determine the relative value of different fungicides in the control of apple scab. In 1908 and 1909 the Bureau of Plant Industry of the U. S. Department of Agriculture co-operated in the work.

The proprietary mixtures were made up in every case as directed on the package. In describing a Bordeaux* the number of pounds of copper sulfate is given before that of the lime; thus a 2-4-50 Bordeaux contained two pounds of copper sulfate and four of lime, to fifty gallons of water. The sodium benzoate Bordeaux contained one pound of copper sulfate, one of lime and one-half pound of sodium benzoate to fifty gallons of water.

In 1907 the first spraying was made May 17, just before the flower buds opened, the second June 7, when the blossoms had mostly fallen and a third June 21. The first spraying was omitted on Plot 20. In the Ladd orchard arsenate of lead at the rate of two pounds to fifty gallons was added to all the fungicides except the Pyrox, which already contained an insecticide. In the Smith orchard Disparene was used as an insecticide.

Notes were taken on the drops August 1, August 27 and October

*For methods of preparing Bordeaux see Bulletin 157 of the New Hampshire Experiment Station.

1. The apples were gathered the first week in October. The results given below are based on a count of the total dropped and picked fruit. The relative position of the plots in the orchard is indicated by their numbers. Each plot consisted of from five to ten trees.

LADD ORCHARD.

| Plot. | Fungicide. | Per Cent. Free from Scab. |
|---|---|---|
| 1 | Bordeaux, Lenox | 20.1 |
| 2 | " Target Quick | 32.3 |
| 3 | " Standard | 36.1 |
| 4 | " Leggett's | 17.2 |
| 5 | " Leggett's Oxidized | 16.6 |
| 6 | " Eagle | 31.2 |
| 7 | " French | 35.6 |
| 8 | " Lion | 9.1 |
| 9 | " Fairmount | 5.0 |
| 10 | Copper Phosphate, 15 lb. to 50 gals. | 17.8 |
| 11 | Bordeaux, 3-4-50 | 42.9 |
| 12 | " Pyrox | 19.0 |
| 13 | " 2-4-50 | 27.0 |
| 14 | None | 14.0 |

SMITH ORCHARD.

| Plot. | Fungicide. | Per Cent. Free from Scab. |
|---|---|---|
| 15 | None | 6.1 |
| 16 | Bordeaux, 4-4-50 | 46.2 |
| 17 | " 3-4-50 | 47.9 |
| 18 | " 2-4-50 | 34.0 |
| 19 | " Sod. Benz. 1-1-½-50 | 29.6 |
| 20 | " Sod. Benz. 1-1-½-50 | 9.3 |
| 21 | None | 6.1 |

The greater percentage of scab on Plot 20 than on 19 must be attributed largely to the omission of the first spraying on the former plot. Plot 20 was adjacent to a check plot but plot 16 was also. The large percentage of scab in the orchards as a whole, was partly due to a late spread of the disease from the unsprayed plots and from those sprayed from inefficient mixtures to other parts of the orchard. This was shown by the large number of young scab spots on the apples at the time of gathering and by notes taken on the

development of the disease at various times during the season. The contrast in the results is, therefore, not so great as the probable contrast in fungicidal value of the mixtures, and none of the plots show as good results as would have been obtained if the whole orchard had been sprayed with the best fungicides.

A chemical analysis was made by the Station chemists of the various Bordeauxs used in the experiments. The first three columns in the following table give the results of analyses of the product as placed on the market. In the fourth column is given the number of pounds of copper sulfate and in the fifth the number of pounds of lime that a fifty gallon barrel of the mixture would contain if made according to the directions furnished by the company.

| Bordeaux. | Water. | Copper Oxide. | Calcium Oxide. | Copper Sulfate Per Barrel. | Lime Per Barrel. |
|---|---|---|---|---|---|
| Pyrox | 65.20 | 2.22 | 3.00 | .35 | .15 |
| Lenox | 67.87 | 1.54 | 17.76 | .49 | 1.78 |
| Lion | 80.00 | 3.12 | 9.70 | 1.00 | .97 |
| French | 81.60 | 3.13 | 4.54 | 2.00 | .91 |
| Grassellis | 50.19 | 7.32 | 22.99 | 2.34 | 2.30 |
| Fairmount | 50.00 | 7.65 | 12.35 | 2.45 | 1.24 |
| Standard | 63.00 | 4.81 | 15.35 | 3.08 | 3.07 |
| Target Quick | | | | 4.00 | 6.00 |
| Eagle | 54.10 | 6.70 | 11.56 | 4.29 | 2.31 |
| Leggett's Blue | 4.00 | 13.73 | 41.28 | 4.39 | 4.13 |
| Leggett's Oxidized | 7.30 | 17.80 | 27.60 | 5.70 | 2.76 |

Tests were not made to determine what other ingredients than copper and calcium compounds might be present. The first three mixtures as given in the above table would have one pound of copper sulfate or less to the barrel if made according to directions. The results obtained in the orchard show that their effectiveness was in keeping with their strength. The Fairmount was a very poorly prepared mixture and gave poor results. The Standard, Eagle and Target Quick were stronger in copper sulfate and it will be noted gave fair results but not as good as home made Bordeaux of weaker strength. The Leggett preparations were in powdered form. They were high in copper but did not control the scab. In addition to this they produced serious injury to the foliage. This was especially true of the oxidized mixture. The copper phosphate also produced decided injury to the foliage and the Eagle Bordeaux slight injury. The foliage was free from injury on all the home

made Bordeaux plots. Considering both effectiveness in controlling scab and safety from injury to the foliage and fruit the results obtained with the 3-4-50 and the 4-4-50 home made Bordeaux were more satisfactory than with any of the other fungicides.

In 1908 the spraying experiments were continued in the same orchards. Some of the Bordeauxs that had given the best results the preceding season were used alongside various sulfur mixtures.

The self-boiled lime-sulfur was prepared according to the directions of W. M. Scott* of the Bureau of Plant Industry, U. S. Department of Agriculture. For the preparation of the 15-10-50 mixture fifteen pounds of fresh stone lime were placed in a fifty gallon barrel and two or three gallons of water were poured over it. Ten pounds of sulfur were immediately added and a few gallons more of water. The heat from the slaking lime soon boiled the mixture violently. Burning was prevented by thorough stirring. If the mass became too thick to stir, more water was added, but the water was kept at a minimum in order to secure the maximum of heat for cooking the mixture. The barrel was covered with a piece of gunny sack to check the escape of the heat. The boiling continued from 20 to 30 minutes. After the boiling had ceased the solution was diluted to fifty gallons for use.

The 9-6-50 self-boiled mixture was prepared by diluting a portion of the 15-10-50 solution. The unboiled lime and sulfur solution was prepared by mixing dilute lime and sulfur paste solutions. No heat was applied and the mixture was merely a mechanical one.

Two commercial lime-sulfur solutions were used, one prepared by the Thomsen Chemical Co., of Baltimore, Md., and the other by the Niagara Sprayer Co., of Middleport, N. Y. The specific gravity of the two stock solutions was approximately the same. As actually applied to the tree, one gallon of the former was diluted to 25 gallons and one gallon of the latter to 50 gallons. The contrast in results obtained should be credited to the difference in dilution and not to a difference in the brands of lime-sulfur used.

The first spraying was made May 15, before the flower buds had opened, the second May 27, when the blossoms had mostly fallen, the third June 10, the fourth June 18, and the fifth July 30. Paris green was used at the rate of 6 oz. to 50 gals. in the second and fourth sprayings. Notes were taken on the drops on August

*Scott, W. M. Self-boiled lime sulfur mixture as a promising fungicide. Bur. of Plant Ind. U. S. Dept. of Agri. Cir. 1, 1908.

14 and at the time of gathering. The apples were picked between September 10 and September 15. The following results are based on the picked fruit and the drops at the time of gathering and were obtained by actual count. The badly scabbed apples were those so seriously damaged by the disease as to be unmarketable.

LADD ORCHARD.

| Plot. | Fungicide. | Applications. | Per Cent. Badly Scabbed. | Per cent. Slightly Scabbed. | Per Cent. Free from Scab. |
|---|---|---|---|---|---|
| 1 | None..... | | 21.9 | 45.2 | 32.9 |
| 2 | L-S, 15-10-50, self-boiled, | 1, 2, 4, 5 | 9.5 | 55.8 | 34.7 |
| 3 | L-S, 9 -6 -50, " " | 1, 2, 3, 4, 5 | 10.2 | 57.8 | 32.0 |
| 4 | L-S, 15-10-50, " " | 1, 2, 3, 4, 5 | 2.9 | 45.0 | 52.1 |
| 5 | L-S, Thomsen, 1-25..... | 1, 2, 3, 4, 5 | .9 | 9.4 | 89.7 |
| 6 | L-S, Niagara, 1-50..... | 1, 2, 3, 4, 5 | 1.3 | 16.5 | 82.2 |
| 7 | Bordeaux, 3-3-50..... | 1, 2, 3, 4, 5 | 1.2 | 18.2 | 80.6 |
| 8 | Bordeaux, Eagle..... | 1, 2, 3, 4, 5 | 1.7 | 24.5 | 73.8 |
| 9 | L-S, 9-6-50, self-boiled.. | 1, 2, 4, 5 | 7.1 | 46.4 | 46.5 |
| 10 | Bordeaux, 3-3-50..... | 1, 2, 4, 5 | 1.2 | 9.4 | 89.4 |
| 11 | Bordeaux, 4-4-50..... | 1, 2, 4, 5 | 2.7 | 5.6 | 91.7 |

SMITH ORCHARD.

| Plot. | Fungicide. | Applications. | Per Cent. Badly Scabbed. | Per Cent. Slightly Scabbed. | Per Cent. Free From Scab. |
|---|---|---|---|---|---|
| 12 | L-S, 9-6-50, unboiled.... | 1, 2, 4, 5 | 23.3 | 42.9 | 43.8 |
| 13 | Bordeaux, Standard.... | 1, 2, 4, 5 | 5.4 | 39.0 | 55.6 |
| 14 | Bordeaux, 3-3-50..... | 1, 2, 4, 5 | 3.6 | 20.6 | 75.8 |
| 15 | Bordeaux, French..... | 1, 2, 4, 5 | 1.6 | 21.0 | 77.4 |
| 16 | Bordeaux..... | 1, 2, 4, 5 | | | |
| 17 | None..... | | 60.4 | 27.9 | 11.7 |

The relative position of the plots in the orchards is indicated by their numbers. The large per cent. of scab on plots 2, 3 and 13 was probably partly due to the spread of the disease from adjacent plots. The third spraying apparently had but little effect upon the amount of scab. The weather following this application was quite dry and it is not surprising that there was but little spread of the disease at that time.

The Bordeauxs seem to have been the most efficient in controlling scab with the commercial lime-sulfurs a close second. The self-boiled and the unboiled lime-sulfur mixtures were quite inefficient and the results would indicate that neither sulfur nor lime, as such,

is a satisfactory preventive for scab. It is possible that the self-boiled mixture would have given better results if it had been made in larger quantities, thus conserving the heat better. All of the plots were apparently free from spray injury.

The Sphaeropsis leaf spot was quite serious in the Ladd orchard. The following table is based on a careful estimate of the condition of the foliage on August 14.

| Plot. | Fungicide. | Per Cent. of Leaves Spotted. |
|---|---|---|
| 1 | None | 95 |
| 4 | Lime-sulfur, self-boiled, 15-10-50 | 21 |
| 5 | Lime-sulfur, Thomsen 1-25 | 26 |
| 6 | Lime-sulfur, Niagara 1-50 | 33 |
| 8 | Bordeaux, Eagle | 26 |
| 9 | Lime-sulfur, self-boiled 9-6-50 | 21 |
| 10 | Bordeaux, 3-3-50 | 26 |
| 11 | Bordeaux, 4-4-50 | 30 |

All of the fungicides gave very satisfactory results on leaf spot, the self-boiled lime-sulfur holding the disease in check better than any of the other mixtures.

The spraying experiments were continued in 1909 in the same orchards. All of the boiled lime-sulfur solutions were diluted to a specific gravity of 1.0117 before using except that used on plot 18 which was diluted to 1.0088. In making the self-boiled lime-sulfur,* 20 lbs. of lime and 20 lbs. of sulfur were used and the mixture later diluted to 100 gallons. An insecticide was added with all the sprayings except the first and the fifth.

The first spraying was made April 26, before the leaves were out, the second May 17, before the flower buds opened, the third June 3, when the blossoms had mostly fallen, the fourth June 24 and the fifth August 13. In the first spraying only plots 6 and 10 were treated the former with copper sulfate, 1 pound to 25 gallons, the latter with a 5-5-50 Bordeaux. In the last spraying only plots 12 to 18 inclusive were treated.

The second spraying was followed by gentle showers and at the time of the third spraying the Bordeaux plots showed serious spray injury.

About the middle of April a fire had escaped from a sugar camp

*Scott, W. M. Lime-sulfur mixtures for the summer spraying of orchards. Bur. of Plant Ind. U. S. Dept. of Agr. Cir. 27, 1909.

and spread over the entire area of the Ladd orchard. A large per cent. of the fallen leaves were destroyed and it was expected that the amount of scab would be thus reduced. The effect was apparently greater than was anticipated as not a scab spot developed on the foliage or fruit in this orchard the following summer, while the checks in the Smith orchard had 14 per cent. of the fruit scabbed and an adjacent McIntosh orchard was badly affected with scab. The scab record as given below for the Smith orchard was based on a count of the total dropped and picked fruit. The record on spray injury was obtained in the Smith orchard by a careful estimate and in the Ladd orchard by an actual count of 500 or more leaves from each plot. Both orchards were practically free from leaf spot. Plots 1 to 10 inclusive were in the Ladd orchard, plots 11 to 17 inclusive in the Smith orchard.

| Plot. | Treatment. | Per Cent. of Fruit Scabbed. | Per Cent. of Leaves Showing Spray Injury. |
|---|---|---|---|
| 1 | None | 0 | 0 |
| 2 | Bordeaux 4-4-50<br>2 lbs. arsenate lead | 0 | 40.2 |
| 3 | Lime-sulfur, Niagara, 1-25<br>6 ozs. Paris green | 0 | 5.0 |
| 4 | Lime-sulfur, boiled, 1-22<br>6 ozs. Paris green | 0 | 21.3 |
| 5 | Lime-sulfur, as plot 4, but 5 lbs. lime and 5 lbs. sulfur added | 0 | .01 |
| 6 | Bordeaux 3-3-50<br>2 lbs. arsenate lead | 0 | |
| 7 | Bordeaux Grassellis<br>2 lbs. arsenate lead | 0 | 37.5 |
| 8 | L-S, self-boiled<br>2 lbs. arsenate lead | 0 | 3.5 |
| 9 | Bordeaux, 3-3-50<br>2 lbs. arsenate lead | 0 | 49.5 |
| 10 | Bordeaux, 3-3-50<br>2 lbs. arsenate lead | 0 | 64.6 |
| 11 | None | 14.0 | 0. |
| 12 | Bordeaux, 3-3-50<br>2 lbs. arsenate lead | 4.2 | 50.0 |
| 13 | Bordeaux, 3-3-50<br>2 lbs. arsenate lead | 4.6 | 50.0 |
| 14 | Lime-sulfur, Grassellis 1 to 24<br>2 lbs. arsenate lead | 1.0 | 0. |
| 15 | Lime-sulfur, Grassellis 1 to 24<br>6 ozs. Paris green | 1.1 | 1.0 |
| 16 | Lime-sulfur, Grassellis 1 to 24<br>no insecticide | 1.4 | 0. |
| 17 | Lime-sulfur Grassellis 1 to 32<br>no insecticide | 1.6 | 0.5 |

The lime-sulfur solutions again controlled the scab as well or better than Bordeaux. The results on spray injury show very striking contrasts. About 50 per cent. of the leaves on the Bordeaux plots showed spray injury while the lime-sulfur plots were practically free from injury. The injury was greater on the lime-sulfur plots where Paris green was used as an insecticide. The addition of lime and sulfur with the Paris green apparently decreased the injury.

The three years' work in the McIntosh orchards indicates that both Bordeaux and lime-sulfur are satisfactory fungicides for the control of scab and leaf spot. The home-made Bordeaux made a better showing than any of the proprietary mixtures and the commercial lime-sulfur better than the self-boiled.

## FOUR YEARS' WORK IN BALDWIN ORCHARDS.

In the summer of 1907 spraying experiments were made in a Baldwin orchard that was known to be infested with fruit spot. The first spraying was made June 17, about two weeks after the blossoms had fallen, the second June 25, the third July 9 and the fourth July 27. It had been found that alkaline conditions would check the growth of the fruit spot fungus in laboratory cultures and it was thought advisable to test the effect of lime on the disease. Plot 6 was treated with a solution having 5 pounds of lime to 50 gallons of water; Plot 7 with a resin lime mixture having 5 pounds of lime and 5 pounds of resin fish oil soap to each 50 gallons of water. The following results were obtained by an actual count of the spotted and unspotted fruit at the time of gathering.

| Plot. | Fungicide. | Applications. | Per Cent. of Fruit Spotted. |
|---|---|---|---|
| 1 | None | | 33.8 |
| 2 | Bordeaux, 3-3-50 | 1, 2 and 3 | 1.1 |
| 3 | Bordeaux, 3-3-50 | 2 and 3 | 1.5 |
| 4 | Bordeaux, 3-3-50 | 3 and 4 | 1.7 |
| 5 | Bordeaux, 3-3.50 | 4 | 20.4 |
| 6 | Lime, 5-50 | 2 and 3 | 16.7 |
| 7 | Resin lime, 5-5-50 | 2 and 3 | 12.9 |

A study of the data shows that the application made on July 9 was more effective than any other, and that the spraying of July 27th materially reduced the disease. While the lime was beneficial

and the resin lime more so, both were far inferior to Bordeaux in controlling the disease. The lime solutions caused no injury while both the first and second applications of Bordeaux caused very serious injury to both foliage and fruit.

The spraying experiments on fruit spot were continued in 1908. The K. L. S. mixture used on plot 7 was a combination of kerosene-limoid and lime-sulfur. In its preparation one pound of lime and one pound of sulfur were added to a gallon of water and the mixture boiled for thirty minutes. Seven and one-half gallons of kerosene and thirty pounds of lime were added to forty-one and one-half gallons of water and the mixture vigorously stirred and churned. The previously prepared lime-sulfur solution was then added with further stirring.

The first spraying was made June 15, the second June 26, the third July 15 and fourth August 1. The following results were obtained by actual count of the picked fruit.

BALDWINS — FIRST ORCHARD.

| Plot. | Fungicide. | Applications. | Per Cent. of Fruit Spotted. |
|---|---|---|---|
| 1 | Resin lime, 5-5-50 | 1 and 2 | 36.1 |
| 2 | Lime-sulfur, Thomsen, 1-25 | 1 and 2 | 54.3 |
| 3 | Lime-sulfur, self-boiled, 9-6-50 | 1 and 2 | 26.5 |
| 4 | Lime-sulfur, self-boiled, 15-10-50 | 1 and 2 | 18.7 |
| 5 | Bordeaux, 2-3-50 | 1 and 2 | 22.2 |
| 6 | None | | 57.8 |

BALDWINS — SECOND ORCHARD.

| Plot. | Fungicide. | Applications. | Per Cent. of Fruit Spotted. |
|---|---|---|---|
| 7 | K. L. S. Mixture | 2 and 3 | 3.4 |
| 8 | Bordeaux, 3-3-50 | 2 and 3 | 2.4 |
| 9 | Bordeaux, 1-3-50 | 1 and 3 | 7.3 |
| 10 | Bordeaux, 2-3-50 | 1 and 3 | 9.3 |
| 11 | Bordeaux, 2-3-50 | 1 and 2 | 8.3 |
| 12 | Bordeaux, 2-3-50 | 1 and 4 | 10.8 |
| 13 | Bordeaux, 2-3-50 | 4 | 47.2 |
| 14 | Bordeaux, 2-3-50 | 1, 2, 3 and 4 | 1.2 |
| 15 | None | | 48.8 |

TOLMAN SWEETS — THIRD ORCHARD.

| Plot. | Fungicide. | Applications. | Per Cent. of Fruit Spotted. |
|---|---|---|---|
| 16 | Bordeaux, 2-3-50 | 2 and 3 | 11.8 |
| 17 | None | | 62.1 |

The results on plot 13 indicate that sprayings made as late as August 1, have little value in controlling the disease. The results as a whole agree with those of the previous year in showing the value of sprayings made in late June or early July. The K. L. S. mixture, the self-boiled lime-sulfur and the Bordeaux gave very satisfactory results. The data on plot 9 shows that fruit spot may be fairly well controlled by a Bordeaux that has but one pound of copper sulfate to the barrel. None of the fungicides produced any injury to foliage or fruit.

In 1910 the comparative merits of Bordeaux and lime-sulfur were given a further test in the Baldwin orchard of A. R. Marsh of Stratham, N. H. In every case the lime-sulfur used was diluted to a specific gravity of 1.010 (a dilution of 1 gallon to about 30). The arsenite of lime was prepared according to the formula of Stewart* of Pennsylvania. The first spraying was made May 7, before the flower buds had opened, and the second May 28, just after the blossoms had fallen. Only plots 2 and 3 received the first spraying. Light showers followed each application. The data on the condition of the foliage is the result of an actual count made June 23. Notes were taken on about 1000 leaves from each plot. The results on the apples were obtained by an actual count of total dropped and picked fruit.

* Stewart, John P., Pa. State College, Agr. Expt. Sta. Bul. 99. 11. 1910.

| Plot. | Fungicide. | Insecticide. | Per Cent. of Apples Scabbed. | Per Cent. of Leaves with Leaf Spot. | Per Cent. of Apples Showing Spray Injury. | Per Cent. of Leaves Showing Spray Injury. |
|---|---|---|---|---|---|---|
| 1 | None | Arsenat lead, 3 lbs. | 49.3 | 30.9 | .0 | 0. |
| 2 | Bordeaux, 3-3-50 | Arsenate lead, 3 lbs. | 51.3 | 6.3 | 36.9 | 71.0 |
| 3 | Lime-sulfur, 1⅜-50 | Arsenate lead, 3 lbs. | 9.0 | 9.0 | 2.1 | 3.8 |
| 4 | Bordeaux, 3-3-50 | Arsenate lead, 3 lbs. | 21.3 | 5.1 | 18.6 | 50.2 |
| 5 | Lime-sulfur, 1⅜-50 | Arsenate lead, 3 lbs. | 45.2 | 6.2 | .0 | .2 |
| 6 | Lime-sulfur, 1⅜-50 | Arsenite lime, 2 pts. | 54.6 | 6.8 | .8 | 16.3 |
| 7 | Lime-sulfur, 1⅜-50 | Paris green, 6 ozs. | 61.5 | 7.2 | .0 | 24.1 |

The numbers of the plots indicate their relative position in the orchard. The orchard sloped toward plot 1. It is evident that lime-sulfur did little to hold the scab in check, even on plot 3 where two applications were given. Both Bordeaux and lime-sulfur gave satisfactory results on the leaf spot. The Bordeaux russeted the fruit, but the injury in most cases was not sufficient to affect the value of the barreled apples. The Bordeaux also spotted the foliage badly. Similar but less severe injury to the leaves was produced by the arsenite of lime and Paris green.

Considering both disease control and freedom from injury the results were not very satisfactory on any of the plots. It is probable that the showers that followed the sprayings were responsible for the Bordeaux injury and that they at the same time washed off enough lime-sulfur to render it inefficient.

The work on fungicides and insecticides was continued the following summer in the Marsh orchards. The first spraying was made May 12, before the flower buds opened, and the second May 26, after the blossoms had fallen. No insecticide was used in the first spraying. The arsenite of lime was prepared as in the preceding season. The commercial lime-sulfur was diluted in every case to a specific gravity of 1.010 (a dilution of about 1 to 30).

Plot 4 was sprayed with a copper sulphid mixture that was very similar to that recommended by Waite *. It was prepared by adding 1½ pounds of copper sulfate, dissolved in 10 gallons of water, to a 10-10-40 self-boiled lime-sulfur solution. The addition of the copper sulfate solution thus brought the lime-sulfur to the 10-10-50 formula, which has been previously described.

Plot 5 was treated with an iron sulphid mixture which had been reported upon very favorably by Waite *. It was prepared by adding 3 pounds of iron sulfate, dissolved in 10 gallons of water, to a 10-10-40 self-boiled lime-sulfur solution.

* Waite, M. B. Experiments on the apple with some new and little known fungicides Bur. Plant Ind. U. S. Dept. Agr. Cir. 58. 1910.

| Plot. | Treatment. | Per Cent. of Leaves with Leaf Spot. | Per Cent. of Leaves with Spray Injury. | Per Cent. of Fruit Russeted. |
|---|---|---|---|---|
| 1 | Arsenate of lead only | 12 | 7 | 2 |
| 2 | Bordeaux, 3-3-50, arsenate lead, 2 lbs. | 0 | 72 | 55 |
| 3 | Lime-sulfur, 1-30, arsenate lead, 2 lbs. | 5 | 12 | 3 |
| 4 | Copper sulfid, arsenate lead, 2 lbs. | 2 | 17 | 37 |
| 5 | Iron sulfid, arsenate lead, 2 lbs. | 6 | 5 | 2 |
| 6 | Self-boiled lime sulfur, 10-10-50, arsenate lead, 2 lbs. | 6 | 7 | 2 |
| 7 | Arsenate of lead only | 18 | 16 | .5 |
| 8 | Lime-sulfur, 1-30, Paris green, 2 lbs., lime, 2 lbs. | 6 | 38 | 18 |
| 9 | Lime-sulfur, 1-30, arsenite lime, 2 pts. | 4 | 35 | 20 |
| 10 | Lime-sulfur, 1-30, arsenate lead, 2 lbs. | 2 | 13 | 1. |

The first six plots were in a different orchard from the last four. All of the trees were Baldwins. There was no scab nor fruit spot on any of the plots. The leaf spot was reduced 50 per cent. or more on every plot treated with a fungicide. Bordeaux caused the most injury of any of the mixtures used, but the per cent. of russeted fruit on the copper-sulfid plot was quite high. The results obtained on the iron-sulfid plot mark this mixture as a promising fungicide. It is interesting to note that Waite obtained very satisfactory results with the iron-sulfid solution. The lime-sulfurs held the leaf spot in check and caused little or no injury. The data on plots 8 and 9 together with similar results obtained the preceding year make it evident that Paris green and arsenite of lime are unsatisfactory insecticides to use with lime-sulfur. Making the arsenite of lime with an excess of lime according to Stewart's formula and adding lime with the Paris green alike failed to remedy the matter.

## SUMMARY AND CONCLUSIONS.

No fungicide has been found that holds diseases in check as well as Bordeaux. When showers follow soon after an application of Bordeaux the leaves are likely to be spotted and the fruit russeted by the fungicide. The injury to the fruit is seldom great enough to be of importance when the apples are sold in barrels. If extra fancy fruit is desired for sale in boxes the use of Bordeaux under New Hampshire conditions seems questionable.

No commercial Bordeaux has been found that is as satisfactory as the home-made and many of the mixtures on the market are practically worthless. (See page 4). A 3-3-50 Bordeaux is the most desirable for use in the apple orchard.

Lime-sulfur has in most cases proven a satisfactory substitute for Bordeaux. It has caused little or no injury and in some seasons has controlled the diseases as well as Bordeaux. The results of 1910 (see page 13) showed that two sprayings of lime-sulfur were entirely inadequate to hold scab in check. When the diseases are serious and the season a rainy one, more applications of lime-sulfur will be required than of Bordeaux. Arsenate of lead is the only insecticide that has proven satisfactory for use with lime-sulfur. Commercial lime-sulfur diluted 2 to 50 has been repeatedly used in New Hampshire orchards without injury, but this strength has sometimes caused injury in other states and a weaker strength is probably desirable. A dilution of $1\frac{1}{3}$ or $1\frac{1}{4}$ to 50 will probably prove most satisfactory. The self-boiled lime-sulfur has given good results on leaf spot but in most cases has not held other diseases in check as well as Bordeaux and commercial lime-sulfur. Its value as a fungicide will vary greatly with the quality of the lime used and the care in making.

The iron-sulfid mixture gave good results in the one season it was used. It is apparently worthy of further trial.

The Baldwin is apparently more susceptible to spray injury than the McIntosh.

The number of sprayings required will vary greatly with the season, with the disease in question and with the general care of the orchard. The removal of all cankers will greatly decrease the leaf spot and the destruction of the fallen leaves is of value in controlling both scab and leaf spot. The application of a strong fungicide before the leaves are out and of one of regular strength just before the flower buds open, will decrease the number of sprayings needed later. By the observance of these precautions the diseases may be greatly checked without any danger to the fruit. In orchards thus cared for one additional spraying just after the blossoms have fallen may be sufficient, if the season is not a rainy one.

For methods of preparing fungicides and for further particulars in regard to the nature of apple diseases see Bulletin No. 157 of the New Hampshire Experiment Station.